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Title: Medium Resolution Gamma Spectrometers for Isotopic Analysis of Uranium and Plutonium at Los Alamos National Laboratory

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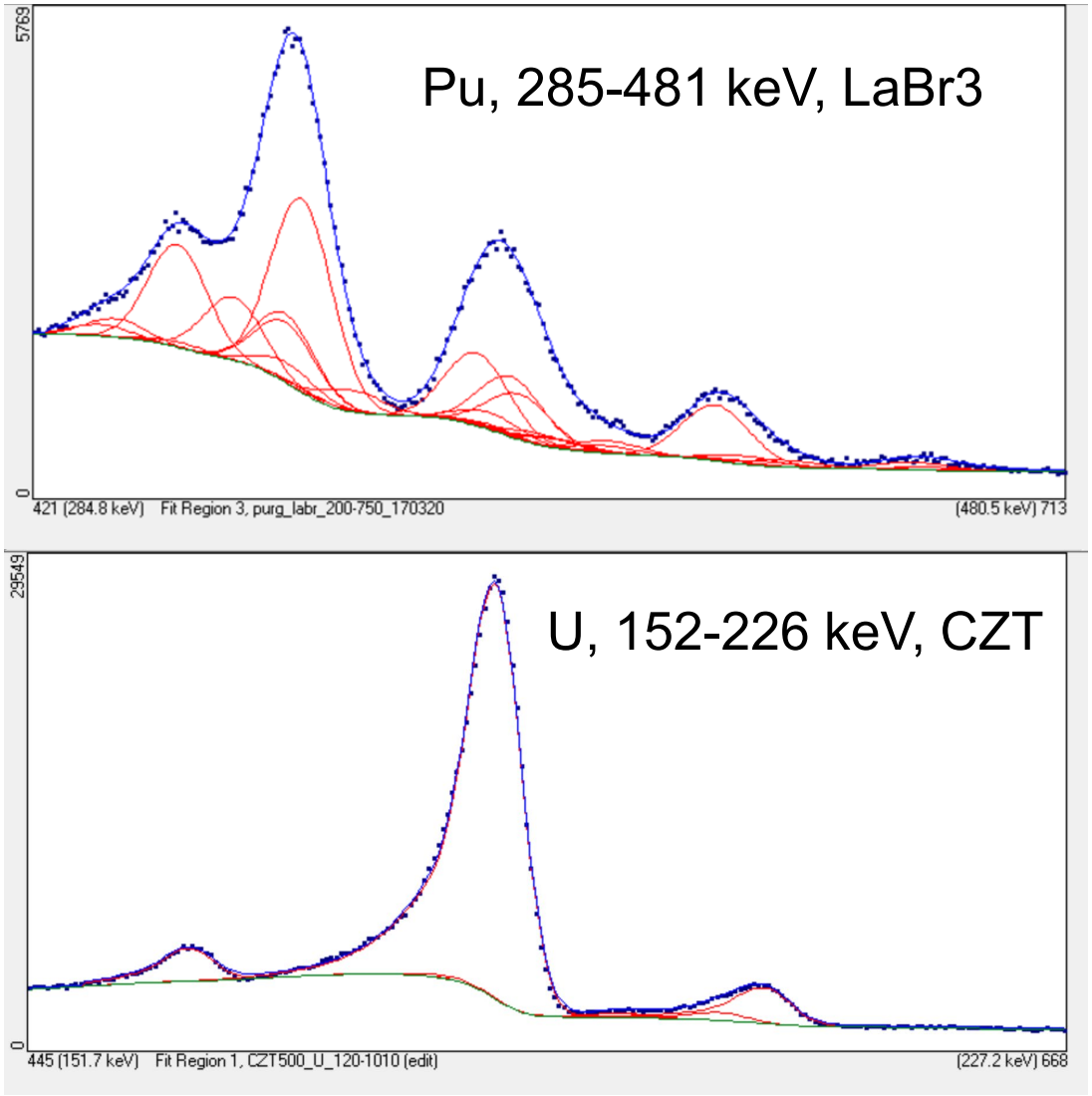
Medium Resolution Gamma Spectrometers for Isotopic Analysis of Uranium and Plutonium at Los Alamos National Laboratory

Duc Vo

FRAM v.6.1

- FRAM v.6.1 (released March 2020) can analyze the MRGS spectra.
- FRAM uses a nonlinear least squares fit technique, combining the Powell's minimization method with the linear least squares fit to fit the peaks of the LaBr3 and CZT spectra.



Uranium ANOVA analysis

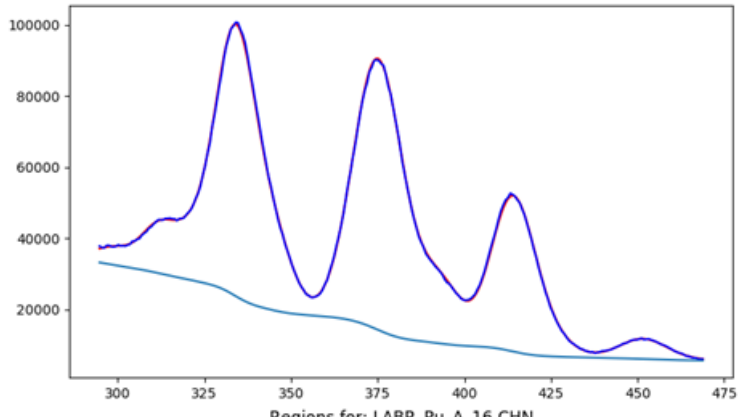
Parameter	Global biases	^{234}U	^{235}U	^{238}U
GePInr_ULEU_060-250 GePInr_UHEU_060-250	Estimate of δ_R	9.0	2.1	8.4
	Estimate of δ_S	1.4	0.9	5.8
	STDEV of Relative Bias	3.8	0.9	6.7
GeCoax_ULEU_120-1010 GeCoax_UHEU_120-1010	Estimate of δ_R	16.0	2.8	2.6
	Estimate of δ_S	1.2	0.7	0.9
	STDEV of Relative Bias	4.3	1.1	1.2
CZT500_U_120-1010	Estimate of δ_R	33.3	32.4	13.6
	Estimate of δ_S	11.3	6.7	23.6
	STDEV of Relative Bias	13.4	10.1	23.6
LaBr_U_120-1010	Estimate of δ_R	9.1	8.8	10.1
	Estimate of δ_S	18.8	9.1	50.9
	STDEV of Relative Bias	18.4	9.3	49.1

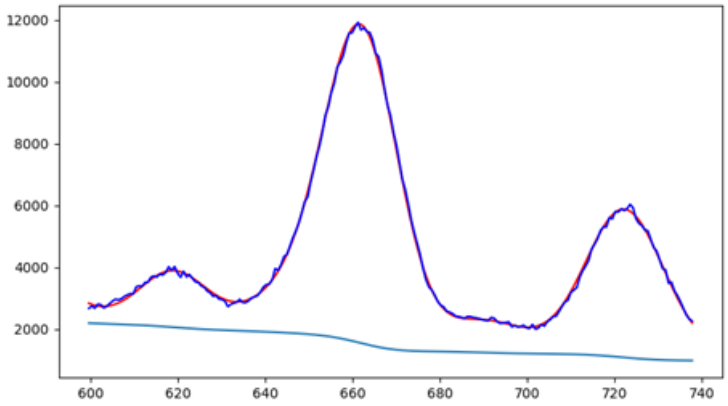
- The random uncertainties δ_R, item-specific systematic uncertainties δ_S, and the STDEV of the relative biases of the MRGS data are about a factor of ten worse than those of HPGe

Plutonium ANOVA analysis

Parameter	Global biases	^{238}Pu	^{239}Pu	^{240}Pu	^{241}Pu	^{241}Am
GePInr_Pu_060-230	Estimate of δ_R	6.0	0.2	0.8	0.5	0.7
	Estimate of δ_S	2.0	0.1	0.7	0.4	1.2
	STDEV of Relative Bias	2.4	0.1	0.8	0.4	1.2
GePInr_Pu _120-420	Estimate of δ_R	6.0	0.4	2.1	0.8	1.4
	Estimate of δ_S	1.9	0.2	0.8	0.4	1.6
	STDEV of Relative Bias	2.4	0.1	0.8	0.4	1.2
GeCoax_Pu _120-420	Estimate of δ_R	6.1	0.3	2.1	0.4	0.8
	Estimate of δ_S	0.8*	0.1	0.7	0.4	1.0
	STDEV of Relative Bias	1.8	0.1	0.9	0.4	0.9
GeCoax_Pu_180-1010	Estimate of δ_R	10.9	0.6	3.3	0.7	1.0
	Estimate of δ_S	7.7	0.4	1.7	0.8	0.9
	STDEV of Relative Bias	7.9	0.4	1.8	0.8	0.9
CZT500_Pu _120-500	Estimate of δ_R	59.8	2.0	26.2	20.8	48.2
	Estimate of δ_S	35.1	0.9	10.2	13.1	17.2
	STDEV of Relative Bias	37.9	0.9	11.0	13.5	25.8
LaBr_Pu _200-750	Estimate of δ_R	83.7	3.7	34.0	11.4	5.3
	Estimate of δ_S	95.2	1.5	12.7	38.1	3.4
	STDEV of Relative Bias	106.0	1.9	16.2	37.9	3.9

MARIA (MARIA Analyses Ratios of Isotope Activities)





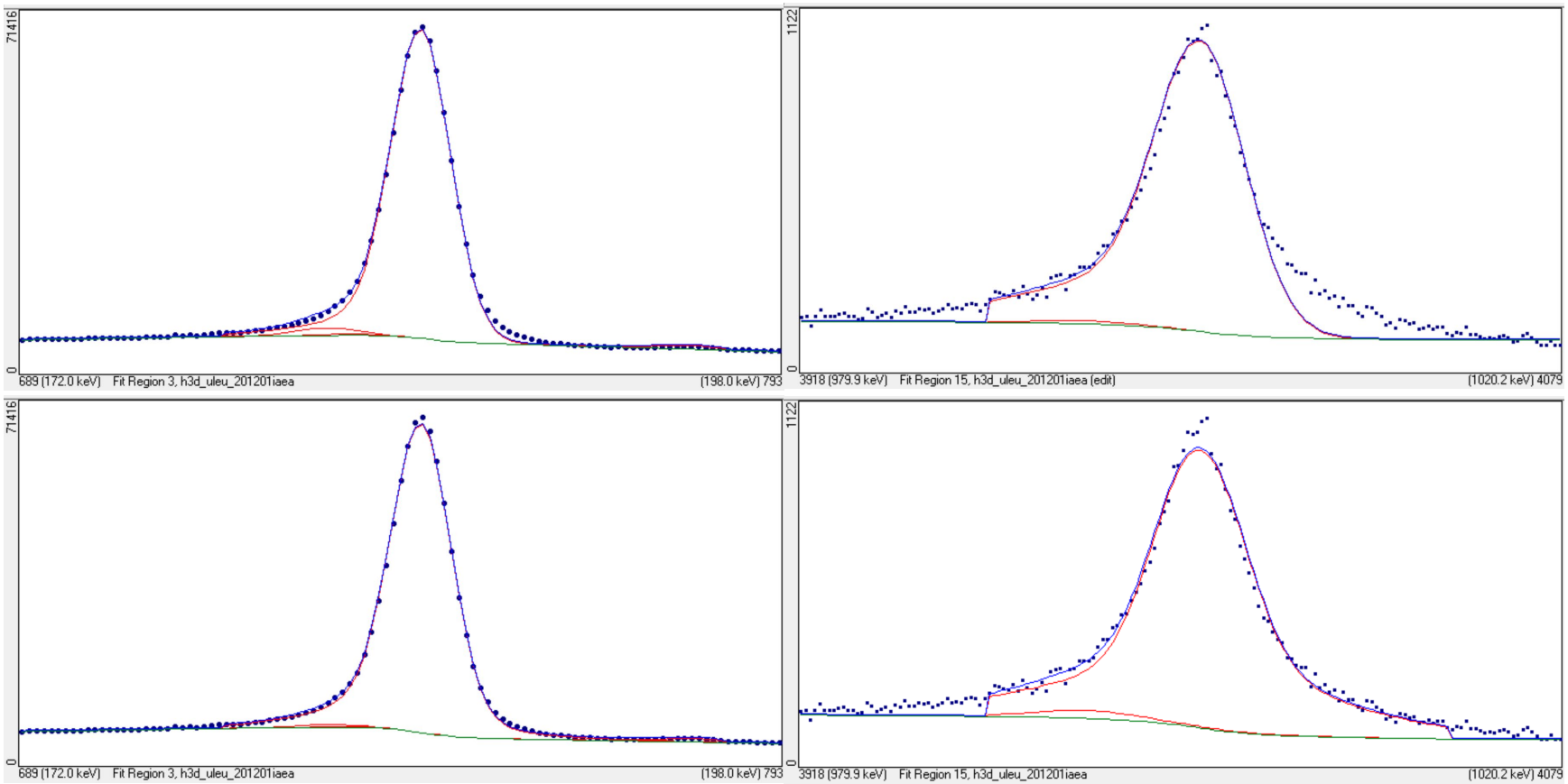
- MARIA analyzes LaBr3 spectra of plutonium and MOX.
- It works better with MOX than plutonium.

Differences between FRAM and MARIA

- FRAM steps:
  - Fit peaks in different regions one region at a time
  - Determine the relative efficiency curve
  - Calculate the relative activities of the isotopes
  - Adjust the background of the analysis regions
  - Repeat the above steps several times

- MARIA fits all the peaks in all the regions, determines the efficiency curve, and calculates the relative activities of the isotopes in one single step.
- MARIA has the potential to be an excellent tool for isotopic analysis of plutonium and MOX spectra acquired by LaBr3 detectors.

H3D CZT peak fitting (high energy tail)



- Left: 186-keV peak; right: 1001-keV peak.
- Top: FRAM v.6.1; bottom: updated FRAM